Kiru Kezuru Migaku

DISCO

Laser Application

Ablation Process

DAL7020

DFL7020

DFL7161

DFL7160

Stealth Dicing

DFL7341

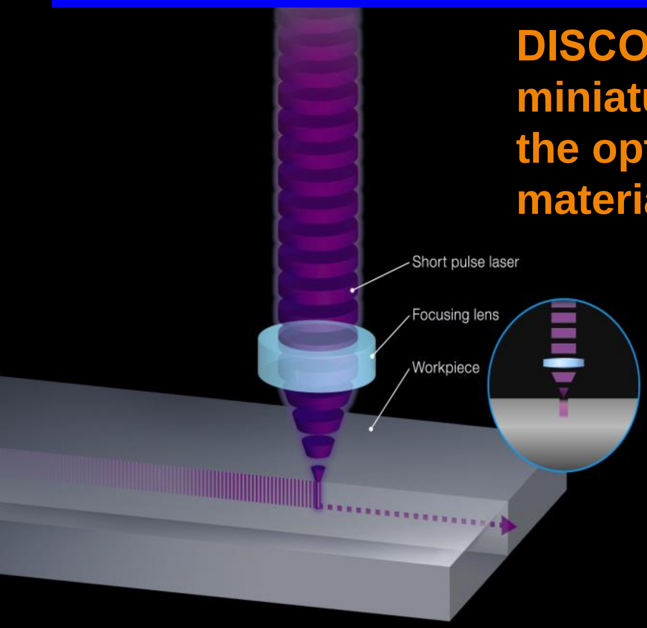
DFL7360FH

DFL7361

Laser Lift Off

DFL7560L

ABLATION PROCESS



DISCO's laser application lineup supports miniaturized next generation devices, providing the optimum *Kiru* technology for various materials.

Kiru **means "cutting" in Japanese.**

What is ablation?

Ablation is a method that sublimes and vaporizes a solid workpiece by irradiating it with a very strong laser for a short period of time.

- Little or no heat damage to the workpiece
- Non-contact processing with a low impact and load
- Ideal for hard workpieces that are very difficult to process
- Able to process fine streets less than 10 µm in width (depending on workpiece conditions)

Compact fully-automatic model for scribing

DFL7020

Smallest model for scribing

DAL7020

High-throughput model

DFL7161

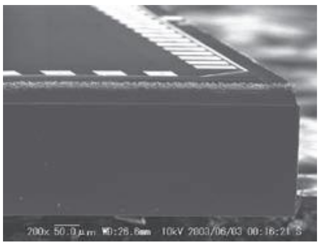
Standard laser saw

DFL7160

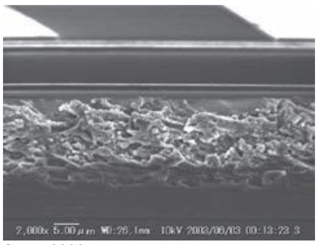
Application Examples

Low-k Grooving

- Inhibits delamination (film peeling)



SEM x200 Feed speed: 600 mm/s Π cut

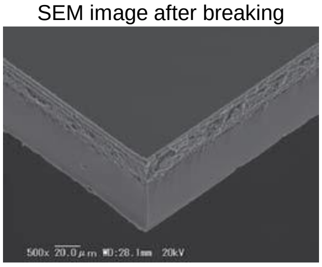


SEM x2000

Sapphire Grooving

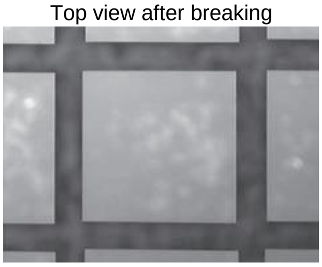
- Realizes stable processing while restraining sapphire brightness deterioration
- Improves CoO with a shape recognition function for broken wafers and with multiple-mounted wafer processing

SEM image after breaking



SEM x500
Wafer thickness: 80 µm

Top view after breaking

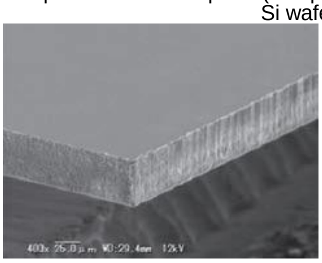


SEM x100
Feed speed: 150 mm/s Wafer thickness: 90 µm

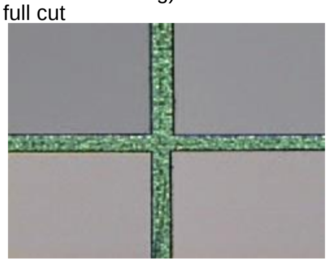
Laser Full Cut

- Increases the number of die per wafer by street reduction
- Improves the feed speed (compared to blade dicing)

Si wafer full cut



SEM x400
Feed speed: 500 mm/s, 3 passes
Wafer thickness: 50 µm



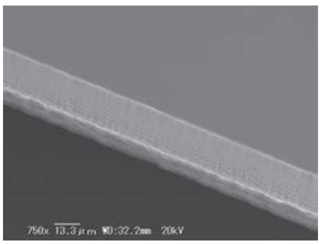
SEM x100

SiC wafer full cut

SEM x150
Wafer thickness: 100 µm

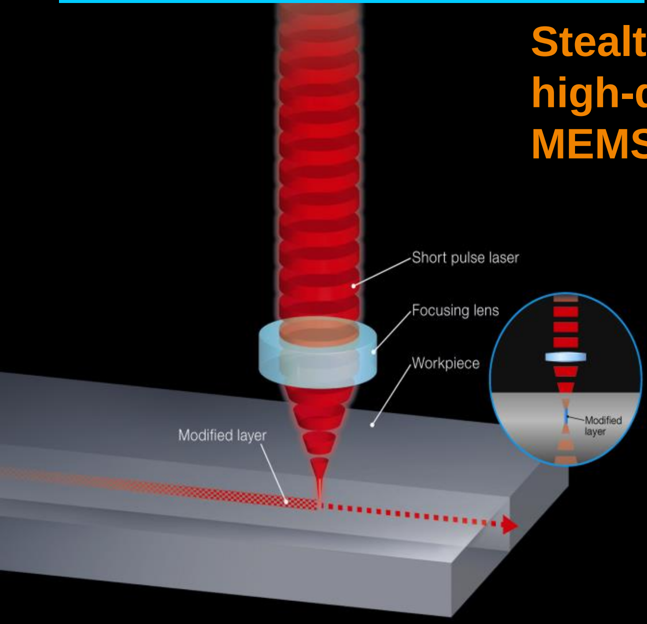
Si+DAF full cut

- High quality cutting of DAF (die attach film)



SEM x750
Wafer thickness: 30 µm DAF thickness: 80µm

STEALTH DICING



Stealth dicing, a new *Kiru* technology, provides high-quality, high-speed wafer processing of MEMS devices and thin wafers.

What is stealth dicing?

Stealth dicing is a processing method that forms a modified layer in the workpiece by focusing a laser inside the workpiece, and then separates the die using a tape expander.

- **Able to control processing waste because it modifies the internal part of the workpiece, making it suitable for workpieces that are vulnerable to contamination**
- **A dry process that does not require cleaning, making it suitable for processes that are vulnerable to loading (e.g. MEMS)**
- **Greatly contributes to street reduction because the kerf width can be made extremely thin**

The DFL7341 and DFL7361 laser saws incorporate an SD engine which has a modularized laser and dedicated optical system.

The SD engine was developed for DISCO by HAMAMATSU Photonics K.K.

High-speed model for sapphire stealth dicing

DFL7341

Supports ø300 mm stealth dicing

DFL7360FH

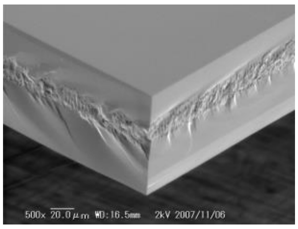
Flagship model with a high degree of process expandability

DFL7361

Application Examples

Silicon wafer

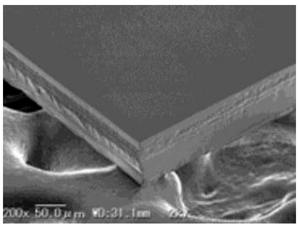
Cross-section photograph



SEM x500
Feed speed: 30 mm/s, 1 pass
Wafer thickness: 100 µm

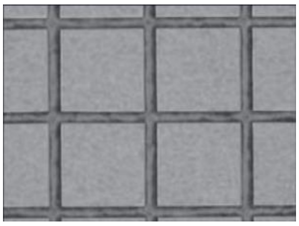
Sapphire

Cross-section photograph



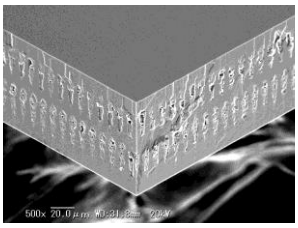
SEM x200
Wafer thickness: 90 µm

Top view photograph



SEM x100
Wafer thickness:100 µm

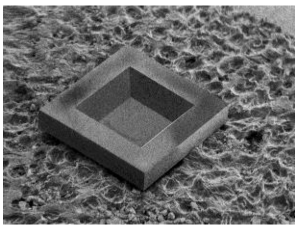
GaAs



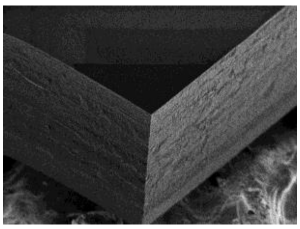
SEMx500
Wafer thickness:100 µm

MEMS

MEMS die

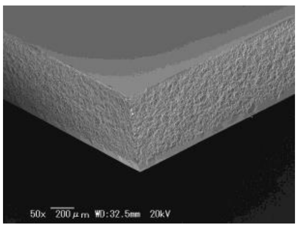


Edge enlargement



Glass

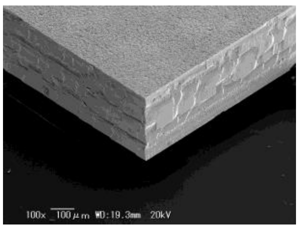
Cross-section photograph



SEM x50 700 µm thick

LiTaO3

Cross-section photograph



SEM x100 350 µm thick

Laser-Based Sapphire Processing
Ablation Process | Stealth Dicing

What is laser-based sapphire processing? A method that uses a laser to process sapphire used as a substrate in high-brightness LED.

Breaking with a diamond scriber was widely used for processing sapphire used as the substrate material in high brightness LED. In accordance with the expansion of the market, however, demands for higher throughput and yield have been increased, thereby expanding the laser processing technology. Laser is now the main method for processing sapphire in high brightness LED.

Advantage of Processing Sapphires with a Laser

DISCO provides two laser processing methods: ablation and stealth dicing. Using a laser for sapphire processing increases yield, improves throughput, and achieves stress-free operation while maintaining brightness equal to the conventional process.

Increased Yield

Uniform processing quality and stable die separation are realized regardless of the skill of the operator just by setting the processing parameter data.

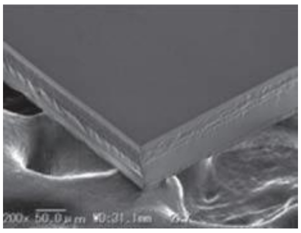
Better Throughput

The very fast feed speed generally enables processing at speeds several times higher than diamond scribing.

Stress-Free Operation

In fully automatic equipment, once the device data has been entered and the cassette has been placed, fully automatic operation can be conducted. The man-hours spent replacing consumables such as expensive diamond probes and the time spent setting data are greatly reduced.

Scribing: After breaking x200



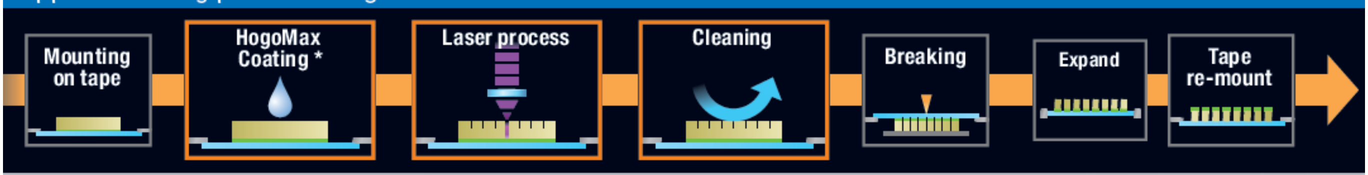
Stealth dicing: After breaking x200

Provides the optimal laser processing in accordance with customers' required processing quality

Ablation scribing is a process which achieves a good balance between cost and brightness, usable for the development of products to the production of high brightness products. Meanwhile, stealth dicing does not deteriorate the brightness, so it is suitable for high-value added devices. Furthermore, since stealth dicing does not have a kerf width, it greatly contributes to street reduction, increasing the number of die to be separated. Conducting several passes enables highly straight die separation even for a thick substrate. DISCO provides stealth dicing so that you can select the optimal laser processing in accordance with your required processing quality.

Process		Diamond scribing + Breaking	DAL/DFL7020	DFL7160	DFL7341
Productivity	Brightness	Excellent	Good	Good	Excellent
	Throughput	Fair	Good	Excellent	Excellent
	Yield	Good	Excellent	Excellent	Excellent
Cost	Equipment initial costs	Excellent	Excellent	Good	Fair
	Running costs (consumables + personal expenses, etc)	Fair	Fair	Good	Good

Sapphire scribing process using ablation



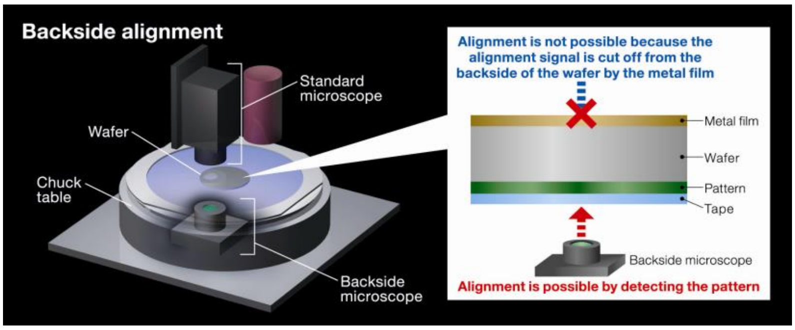
Sapphire processing using stealth dicing

Note: The HogoMax Water-soluble protective film coating function is an optional specification.

Alignment of Wafers with Backside Metal Film

In applications where a laser is irradiated from the side opposite to the wafer pattern surface for processing, alignment must be performed through the wafer. However, if metal film is attached to the backside, alignment cannot be performed and the process cannot be used. The backside alignment mechanism enables alignment from the chuck table side for these types of wafers.

(The backside alignment unit is an optional specification used only in ablation.)



Laser Grooving

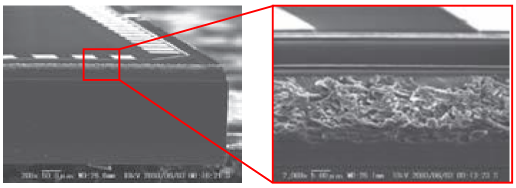
Ablation Process

What is laser grooving ? A processing method that forms a narrow groove in the cut street using a laser.

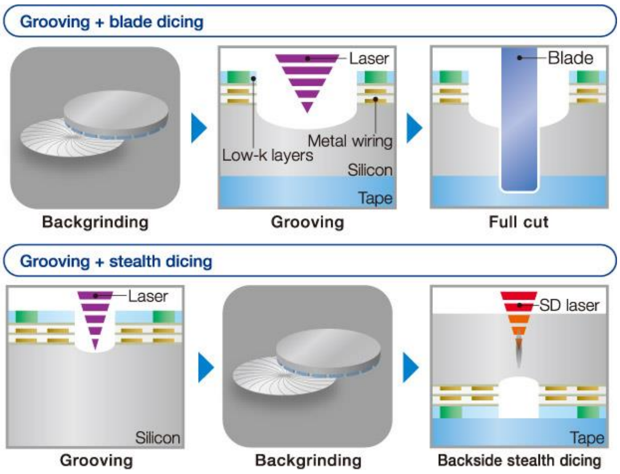
Laser grooving is suitable for wafers with low-k film (low dielectric constant) commonly used for the miniaturization of semiconductor devices. After forming a narrow groove with a laser in these difficult-to-cut materials, the die are separated using a blade or laser dicing.

Low-k Film & Metal Layer Grooving

Delamination (film peeling) can be a problem when blade dicing of wafers with low-k film. Laser grooving, which has no mechanical load, can be used to achieve high-quality processing with minimal delamination, thereby contributing to higher productivity. DISCO laser grooving is also used in applications where the metal layer (TEG, wiring, circuits, etc.) is removed along the dicing street.



Low-k Grooving Examples



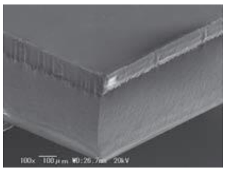
Performing laser grooving prior to blade dicing enhances the quality and throughput when processing low-k wafers.

Combining laser grooving and stealth dicing achieves significant street reduction.

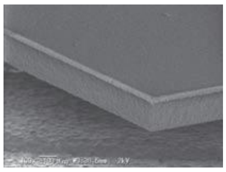
Scribing on Hard-to-Cut Materials + Breaking

The materials below, which are difficult to cut with a blade, can now be made into die by laser scribing followed by breaking.

- **Aluminum nitride used in heat sink materials**
- **Gallium nitride used in laser diode materials**
- **Alumina ceramics, SiC, etc.**



Alumina ceramics SEM x100
635 µm thick



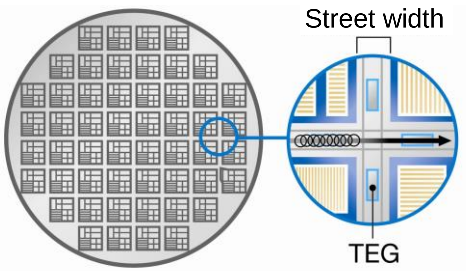
Aluminum nitride SEM x100
150 mm/s, 1 pass, 200 µm thick

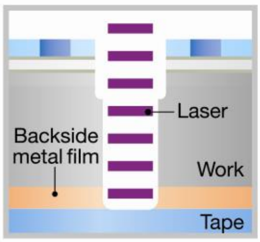
Laser Full Cut

Ablation Process

What is a laser full cut ? A method that completely cuts the workpiece only with a laser process.

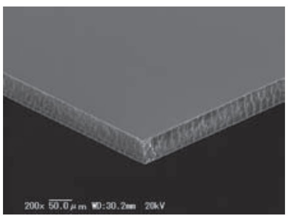
A laser full cut is effective for thin silicon, compound semiconductors, wafers with backside metal film, high-brightness LED substrates, and metals (Cu, molybdenum), and normally cuts into the tape by irradiating a laser for one to several passes on the patterned surface. This method realizes high-speed, high-quality processing and significant street reduction by focusing the laser beam on a spot less than 10 µm in diameter. This laser process also enables a Si + DAF (die attach film) full cut.





Thin Silicon Wafer Full Cut

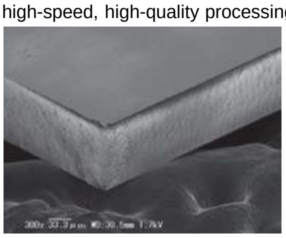
This process realizes high quality, high-speed full cutting with a laser on thin silicon wafers that are very difficult to process.



SEM x100
200 mm/s, 1 pass, 50 µm thick

Compound Device Full Cut

Previously, when processing compound semiconductors such as GaAs and SiC, high productivity could not be achieved since it was difficult to increase the feed speed in the existing blade dicing. The non-contact and low-load laser process enables high-speed, high-quality processing.

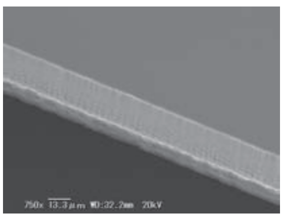


GaAs

SEM x300
140mm/s, 1 pass, 100 µm thick

Si + DAF Full Cut

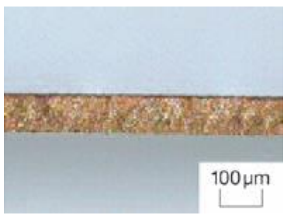
Uncut DAF (whiskers) tends to occur when dicing DAF with a blade. Laser cutting can significantly reduce this.



SEM x750
Wafer thickness: 30 µm, DAF thickness: 10 µm

Metal Full Cut

The laser enables high-quality and high-speed full cuts of metals such as Cu and molybdenum used in high-brightness LED substrates and heat sink. The kerf loss can also be reduced.



Cu

Cu full cut x100

Hasen Cut

Ablation Process **Stealth Dicing**

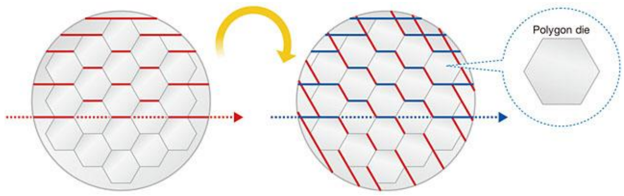
What is a Hasen cut? **A processing method involving laser irradiation in a broken (dotted) line.**

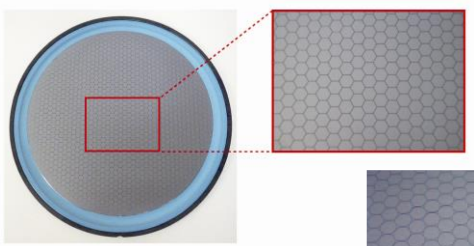
In a Hasen cut, the laser can be turned on and off at any point to process workpieces with different die sizes and polygonal-shaped workpieces, supporting a wide range of applications.

Processing Polygonal-Shaped Die

Linear processing can be combined to enable processing of hexagonal, octagonal, and other polygonal shapes.

Continuous polygonal-shaped die are processed by combinations of linear processing.

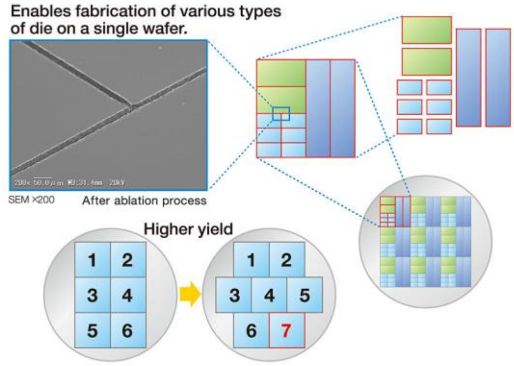




Wafer after stealth dicing + expansion

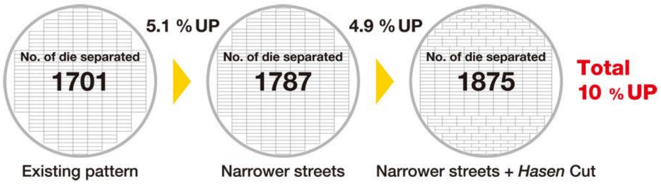
Multi-project Wafer (MPW) Processing

Processing is also possible for sample wafers, evaluation wafers, and other wafers with varying sized die. Processing is even possible for wafers where the die are offset in order to increase the yield of long or other irregular-sized die.



Synergetic Effect by Combining Stealth Dicing and the Hasen Cut

Processing is possible for sample wafers, evaluation wafers, and other wafers with varying sized die. Processing is even possible for wafers with long or other irregular-sized die where the die are offset in order to increase the yield.

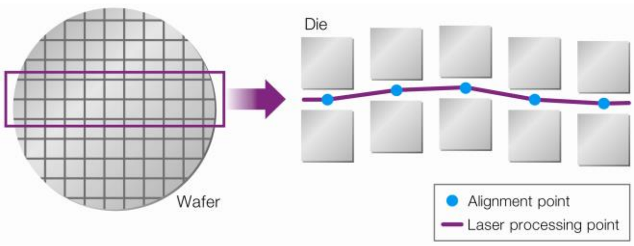


DBG + DAF Laser Cut

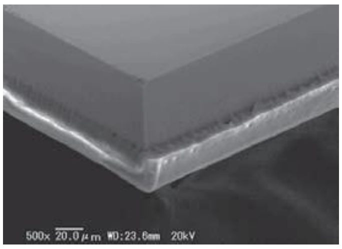
Ablation Process

What is a DBG + DAF laser cut? **A process that cuts the DAF with a laser after the DBG process.**

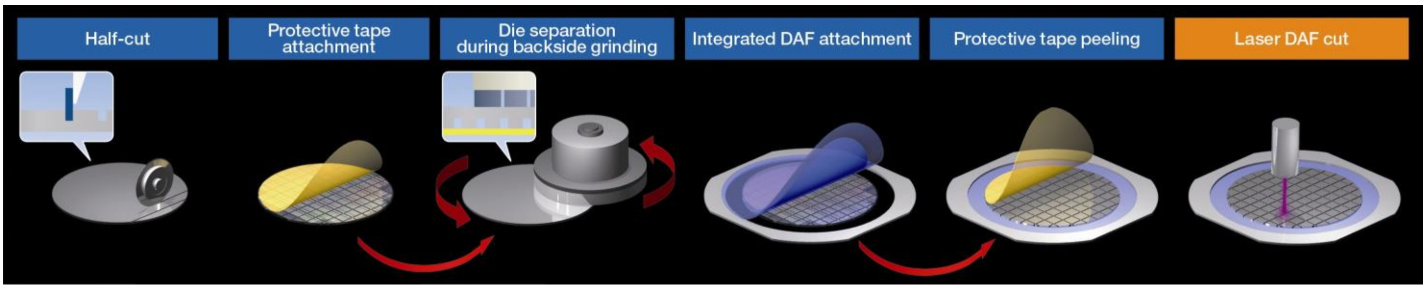
The DBG (dicing before grinding) process, which separates die during backgrinding after half-cut dicing, lowers backside chipping, improves die strength, and is expected to lower the risk of damage in thin wafers. The DBG + DAF cut process attaches DAF to the backside of a wafer for which the die were separated in the DBG process, and then cuts only the DAF. Laser DAF cutting is effective because it can process shifted die and improves processing quality. When DAF is applied to the DBG process, it is possible to use DBG in the production of the ultra-thin die used in SiP.



If die shifting occurs after DBG processing, a process that tracks the shift is possible using special alignment. This alignment records the kerf center position for each alignment point of every line. The laser then cuts this center position.



SEM photograph after DBG + DAF cut
SEM x500, 200mm/s
Si: 70 µm thick
DAF: 20 µm thick



HogoMax003

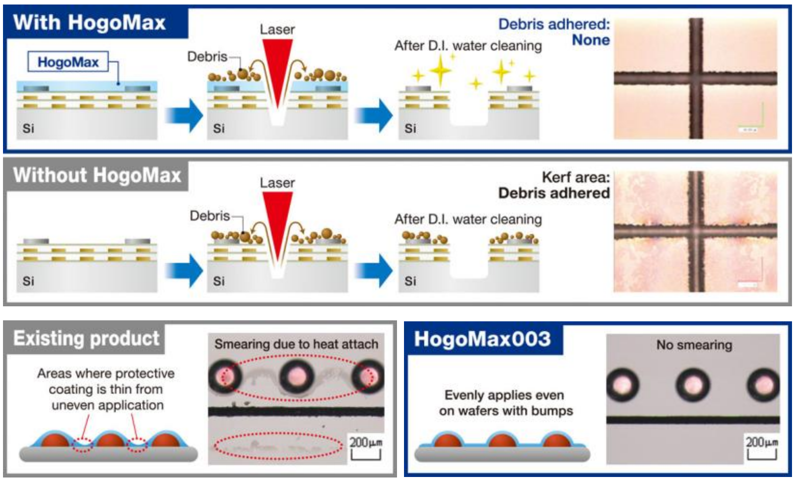
Ablation Process

What is HogoMax003? | **A water-soluble protective film that prevents thermal adhesion of the protective film and contributes to increased yield.**

Laser processing particles (debris) generated during the ablation process cannot be removed by deionized water cleaning once attached to the wafer surface. Debris causes device defects such as bonding defects and increased current leaks. HogoMax, an original water-soluble protective film developed by DISCO, contributes to the improved reliability of devices when applied to the processing surface before laser processing by greatly reducing the adhesion of debris. Moreover, HogoMax003 can be applied evenly and prevents thermal adhesion of the protective film, contributing to a boost in yield.

Prevents Debris Adhesion on the Wafer Surface

- Coating the laser processing surface with HogoMax prevents adhesion of debris during processing.
- Due to the superior processability by UV laser, the protective film surrounding the processing point does not peel.
- The film can be removed after laser processing just by cleaning with deionized water.



Best Suited for Laser-Processing on a Concave/Convex Wafer

- With conventional products, the protective film between bumps becomes thin due to surface tension, causing coating irregularities. Thermal adhesion occurring at thin areas of the protective film during processing and causing stains is also an issue.
- HogoMax003 eliminates coating irregularities between bumps and prevents thermal adhesion.

Full-Auto Processing From Coating to Cleaning

- HogoMax makes it possible to process fully automatically from HogoMax coating to laser processing and deionized cleaning. (The coating function is an optional specification. Applicable models: DFL7020, DFL7161, DFL7160)

Laser Lift-off

Laser Lift-off Process

What is laser lift-off? | **A method that detaches the material layer from the substrate by irradiating a laser on the material layer formed on the substrate.**

Laser lift-off is a process for peeling substrates made of sapphire or glass. It is used for peeling off the sapphire substrate from the crystal layer of GaN (gallium nitride) compound materials, which are primarily used for making vertical structured blue LEDs.

High-Yield and Low-Running-Cost Manufacturing

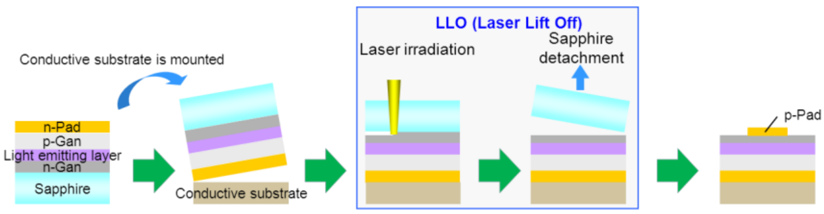
- Employs a solid-state laser to save a significant amount of maintenance time (reducing the frequency of replacing consumable products and adjusting the optical axis), achieves stable processing quality, and improves productivity.
- Employs DISCO's original optics system to process at an extensive focal range with optimal power. This suppresses wafer damage and minimizes detachment failures. In addition, the surface roughness after detachment becomes one-third of the current value.

Laser lift-off model with a solid-state laser

DFL7560L

Example of Applicable Processes: Sapphire Substrate Detachment for V-LED

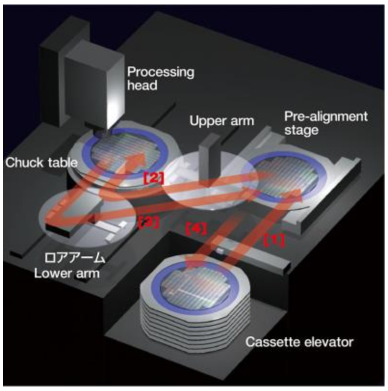
- The light emitting layer is remounted on a highly exoergic conductive substrate for the purpose of improving brightness and better heat sink. LLO is used in this sapphire substrate detachment process.



Precautions for the Patent: If laser lift-off is performed for LED, please note that you may be in violation of patent nos. 4285776 in Japan and US6071795 and US6420242 in other countries.

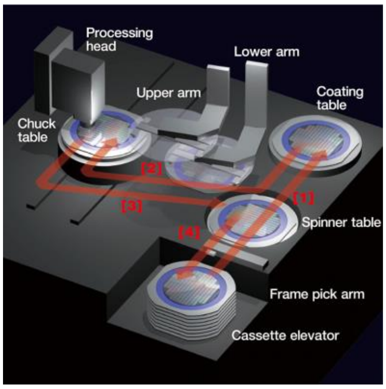
Operation Flow

Ablation Process



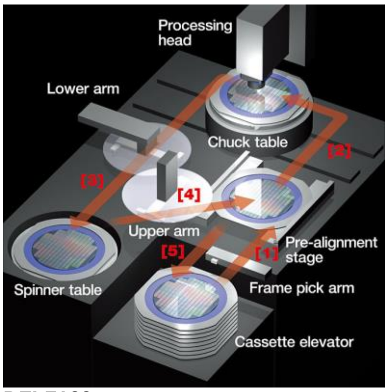
DFL7020

① Frame pick arm moves workpiece out of cassette to pre-alignment stage → HogoMax coating
② After centering at pre-alignment stage, the handling arm transfers the workpiece to the chuck table → laser processing
③ Handling arm transfers the workpiece to the pre-alignment table → cleaning
④ Frame pick arm returns workpiece to cassette



DFL7161

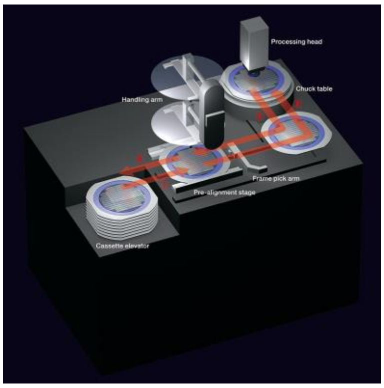
① Frame pick arm moves workpiece out of cassette → After centering, the workpiece is transferred to the coating table → Protective film coating
② Upper arm moves workpiece to chuck table → laser processing
③ Lower arm moves workpiece to spinner table → cleaning
④ Frame pick arm returns workpiece to cassette



DFL7160

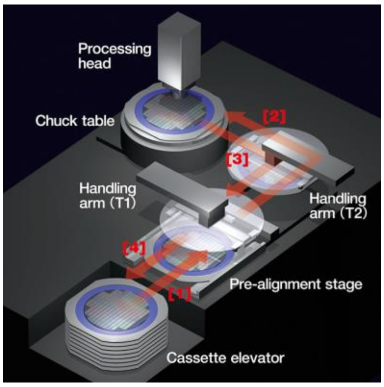
① Frame pick arm moves workpiece out of cassette to prealignment stage
② After centering at pre-alignment stage, upper arm moves workpiece to chuck table → laser processing
③ Lower arm moves workpiece to spinner table → cleaning and drying
④ Upper arm moves workpiece to pre-alignment stage
⑤ Frame pick arm returns workpiece to cassette

Stealth Dicing



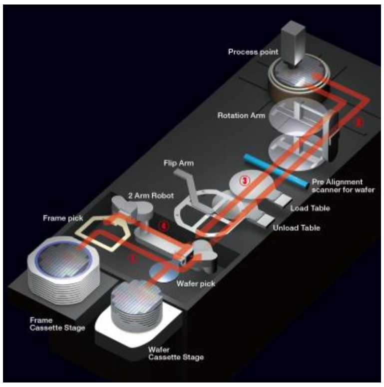
DFL7341

① Frame pick arm moves workpiece out of cassette to pre-alignment stage
② After centering at pre-alignment stage, upper arm moves workpiece to chuck table → laser processing
③ Lower arm moves workpiece to pre-alignment table
④ Frame pick arm returns workpiece to cassette



DFL7360FH

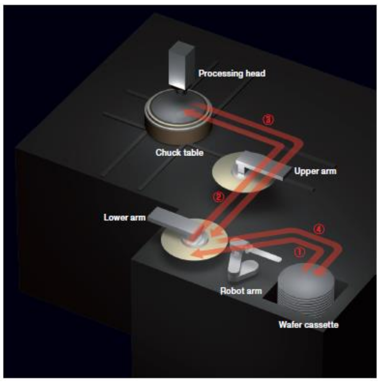
① Frame pick arm moves workpiece out of cassette to pre-alignment stage
② After centering, the handling arm transfers workpiece to chuck table → laser processing
③ Handling arm transfers workpiece to pre-alignment table
④ Frame pick arm returns workpiece to cassette



DFL7361

Wafer transfer (Standard specification)
①The workpiece is withdrawn from the cassette by the wafer pick and transferred to the load table
②The workpiece is transferred to the chuck table by the rotation arm → laser processing
③The workpiece is transferred to the unload table by the rotation arm
④The workpiece is returned to the cassette by the frame pick

Laser Lift-off



DFL7560L

① Unload workpiece from cassette to upper arm
② Transfer workpiece to C/T with Upper arm → laser processing
③ Transfer workpiece from C/T to robot pick with lower arm
④ Robot pick returns workpiece to cassette

7000 Series Specifications

			DFL7020	DAL7020	DFL7161	DFL7160
Processing method			Ablation			
			Fully automatic	Automatic	Fully automatic	
Workpiece size		mm	φ 150	φ 150	φ 300	φ 300
X-axis (Chuck table)	Processing range	mm	155	155	310	310
	Max. processing speed	mm/sec	0.1 - 300	0.1 - 300	0.1 - 1000	0.1 - 600
Y-axis (Chuck table)	Processing range	mm	162	162	310	310
	Index step	mm	0.0001	0.0001	0.0001	0.0001
	Positioning accuracy	mm	0.003/160 (Single error)0.002/5	0.003/160 (Single error)0.002/5	0.003/310 (Single error)0.002/5	0.003/310 (Single error)0.002/5
Z-axis	Moving resolution	mm	0.00002	0.00002	0.00005	0.00005
	Repeatability accuracy	mm	0.002	0.002	0.002	0.002
θ-axis (Chuck table)	Max.rotating angle	deg	320	320	330(standard) 380(option)	380
Machine dimensions(W×D×H)		mm	1,050 × 1,530 × 1,650	600 × 1,500 × 1,530	1,560 × 1,550 × 1,800	1,200 × 1,550 × 1,800
Machine weight		kg	Approx.1,310	Approx.810	Approx. 2,300	Approx.1,750

			DFL7341	DFL7360FH	DFL7361
Processing method			Stealth Dicing		
			Fully automatic		
Workpiece size		mm	φ 200	φ 300	φ 300
X-axis (Chuck table)	Processing range	mm	210	310	310
	Max. processing speed	mm/sec	1 ～ 1,000	1 – 1,000	0.1 - 1,000
Y-axis (Chuck table)	Processing range	mm	210	310	310
	Index step	mm	0.0001	0.0001	0.0001
	Positioning accuracy	mm	0.003/200 (Single error)0.002/5	0.003/310 (Single error)0.002/5	0.003/310 (Single error)0.002/5
Z-axis	Moving resolution	mm	0.0001	0.0001	0.0001
	Repeatability accuracy	mm	0.001	0.001	0.001
θ-axis (Chuck table)	Max.rotating angle	deg	380	380	380
Machine dimensions(W×D×H)		mm	950 × 1,732 ×1,800	1,100 × 2,100 × 1,990	1,210×3,270×1,800
Machine weight		kg	Approx. 1,800	Approx. 2,060	Approx. 2,570

			DFL7560L
Processing method			Laser Lift-off
			Fully automatic
Workpiece size		mm	φ 150
X-axis (Chuck table)	Processing range	mm	210
	Max. processing speed	mm/sec	1～1,000
Y-axis (Chuck table)	Processing range	mm	210
	Index step	mm	0.0001
	Positioning accuracy	mm	0.003/210 (Single error)0.002/5
Z-axis	Repeatability accuracy	mm	0.002
Machine dimensions(W×D×H)		mm	2,000 ×1,810 × 1,800
Machine weight		kg	Approx. 3,300

Environmental Conditions

- Use clean, oil-free air at a dew point of -15ºC or less. (Use a residual oil: 0.1 mg/m³ or less. Filtration rating: 0.01 µm/99.5 % or more).
- Keep room temperature fluctuations within ±1ºC of the set value. (Set value should be 20-25ºC)
- The machines should be used in an environment free from external vibration. Do not install the machines near a ventilation opening, heat-generating equipment, or oil mist generating parts.

* The above specifications may change due to technical modifications. Please confirm when placing your order.
* All the pressures are described using a pressure gauge.

Laser Safety

- This product uses invisible light. Please handle with extreme care.
- Avoid eye or skin exposure to direct or scattered laser light.
- Do not place shiny objects such as metals in the laser path.
- The above seven models correspond to a Class 4 laser under CDRH or IEC standards but meet safety standards so that they can be used as a Class 1 laser product (CDRH:21 CFR1040, Performance Standards for Laser Products Source, IEC Publ.60825-1: Laser Product Safety Part 1)
- Before using the machine, thoroughly read the manual and follow the instructions set forth in the manual.
- Never attempt to modify or repair the machine in a manner not approved by DISCO.